

Revitalization of an undergraduate physics program

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This article describes the successful revitalization of an undergraduate physics program. The areas of curriculum development, undergraduate research experiences and advising and retention, to name a few, are emphasized in this interconnecting and systematic approach whereby each and every effort combines to get results. The program can be used by other physics departments wishing to improve and expand undergraduate education in physics.

1 Introduction

Undergraduate physics programs in the United States and other countries seem to be in a period of decline. There are less students taking the physics major and less students entering graduate study [1]. Some departments are being closed down and others are under the threat of closure. In such circumstances demoralization sets in and spirals into every aspect of a program discouraging faculty and students.

Five years ago the physics department at the University of Wisconsin - La Crosse had a total of 5 physics majors, 5 faculty and a graduation rate of about one physics major every two years. The department had received a poor review and was in danger of being phased out, but instead of taking this easy option the dean of the college decided instead to hire a new chair in an attempt to turn the department around. Five years later the department is one of the best on campus, has received an excellent review and currently has a total of about 85 physics majors and 7 faculty. The present article describes how this was achieved. It is hoped that the information presented here can be used by other physics departments to revitalize their programs.

2 Program outline

1. Academic Programs. The first thing was to change the academic programs being offered and re-package them in attractive ways directing students, parents and teachers to expand their typical view of what a physics degree could do for the student. We still continued the core subjects of modern physics, mechanics, electrodynamics, quantum mechanics, thermodynamics and optics. We also continued two popular astronomy courses and the introductory year long sequences of algebra and calculus based physics courses. However several new courses were added to make the elective list a lot more interesting and useful for the students. Some of the electives added were quantum optics, electronics, seminar (for credit), research (for credit), computational physics and advanced computational physics, general relativity and cosmology, astrophysics, advanced quantum mechanics and particle physics.

2. Emphases and Concentrations. One of the important additions in attracting new majors was the introduction of a set of emphasis programs that could be packaged along with course and career information. These included physics major with business concentration, physics major with astronomy emphasis, physics major with computational physics emphasis and physics major with optics emphasis.

The physics major with business concentration basically consisted of a physics major with a business minor for a total of about 55 credits. Why go to the trouble of simply re-packaging an already existing product (physics major and business minor) into a 'new' product (physics major with business concentration)? This is an important point and should not be lost. Physics now needs to be marketed as does any other product, and the department has to have the products to suggest and then deliver to students. Physics programs now need to be attractive not only to students, but also to parents and teachers, who heavily influence the students. Often these clients simply don't think of physics and business as going together, yet most of us in the field know that this is an excellent combination for students wishing to obtain employment with a bachelors degree. Having a formal program such as a physics major with business concentration highlights the career opportunities available to students and simply makes the overall physics program look a better match in today's job market. A quick perusal of job sections in newspapers show marketing/sales in technical areas, computer and technology skills being needed in the business sector. These are all skills taught

in a physics degree (with business concentration).

In order to be able to offer these emphases the department had to add quite a few courses to the catalog, as mentioned above. The areas of optics, computational physics and astronomy were chosen deliberately. Optics is very important for industry and is a good area for job seekers. Computational physics is also an excellent area for both job seekers and those wishing to go to graduate school. Astronomy was chosen simply because so many students have an interest in this area. It was also important to make sure that the department had expertise in these areas. Aside from offering the regular physics major, three areas of emphasis were introduced namely optics, astronomy and computational physics. The total number of credits for these three programs was similar to the regular physics major, but the elective options were eliminated. Instead, the electives were chosen for the students. For the astronomy emphasis the student was required to take the core physics courses plus 3 astronomy courses and a research project in astronomy. Similarly for the optics and computational physics emphasis. An optics experimentalist was hired to help with this. One can easily imagine other departments with different areas of expertise developing different emphasis programs. There are many departments that already have an extensive listing of electives. From the student, parent, teacher point of view however, the existence of these electives and what they can do is often lost. It is very worthwhile to package some strong elective programs into emphasis areas so that it is clear as to what specializations are available to students and how this relates to the real world task of getting a job.

3. Honors Program. A physics honors program was also introduced, in which students are required to submit a formal application, maintain a certain GPA, complete a research project with distinguished performance, give a seminar and be recommended by two faculty members.

4. Dual degree in physics and engineering. One of the most important programs introduced was a dual degree program in physics and engineering. Such programs are starting to gain popularity and are an excellent way to revitalize an undergraduate physics department. The program introduced was a collaborative program between our own department and two engineering schools (University of Wisconsin - Madison and University of Wisconsin - Milwaukee). An essential feature of this program is that a student is guaranteed acceptance into the engineering school upon completion of a set of physics and other required courses with a specified grade point average. The

students spend 3 years in the department at the University of Wisconsin - La Crosse studying selected physics courses and then transfer to one of the engineering schools for 2 years to study an area of engineering. After the first year at the engineering school the student receives a physics degree from La Crosse and after the second year receives an engineering degree, thus graduating with two degrees that complement each other. This program has been extremely attractive to students, parents and teachers. We strongly recommend such a program to undergraduate physics departments.

5. Laboratory Upgrades. As part of improving the academic programs, a lot of attention was paid to upgrading the laboratory facilities. During the past five years approximately \$200,000 in laboratory modernization funds were spent in upgrades. One cannot expect students first and facilities later. They only come together. The freshman physics labs were completely overhauled using computer based "workshop physics" style laboratories. The students went from hating lab work to actually enjoying it. In addition the modern physics lab, optics lab and electronics lab were completely re-done with a full complement of modern experiments and equipment.

6. Quality Instruction. The quality of instruction in all courses (but especially the introductory courses) was improved by trying very hard to use the best instructors. This seems mundane, but is extremely important in building up a physics program. If the majors have a couple of, or even one, poor instructor then the program suffers tremendously. It is absolutely vital to have high quality instruction and every effort must be made to make sure this happens.

7. Undergraduate Research. One of the major factors that lead to high student satisfaction with our new program was a strong set of research experiences for the undergraduate physics majors. Before we came to the department, research was almost non-existent. As an incentive to faculty the chair allowed supervision of undergraduate research to count for one course for the faculty member and as an incentive for students we introduced research for credit that a student could take. Further to this a research experience was a requirement for each of the 3 emphasis programs described above. Three out of the six faculty became actively involved in student research projects immediately. Research was offered in all three areas of experiment, theory and computation in the areas of optics, condensed matter physics, particle physics, nuclear physics and astronomy. Several students worked only on semester-long projects, but the most successful experiences were with stu-

dents who would work for two semesters and one summer. The advantage of this work is many-fold. Fliers to schools, brochures, campus news, department annual reports, student and faculty resumes all are enhanced.

Many good undergraduate departments have such an undergraduate research program in place. When talking to administrators about physics we often emphasize the triad of theory, experiment and computation. When talking about physics education we emphasize the triad of lecture, laboratory and research. It is vitally important for undergraduates to have a good research experience during their education. It also helps the department atmosphere tremendously and is very good to display when giving tours to students, parents, teachers and administrators.

8. Student Presentations. The research outlined above could be showcased to other students or advertised, and so attracted further students. Students were encouraged and trained to present the results of their work at department seminars and at conferences such as the Argonne symposium [2-9] and also at national and international meetings such as the American Astronomical Society and the International Symposium on Molecular Spectroscopy [10-13]. Many students and faculty published papers together [14-21]. Faculty benefitted also by being able to place any of the work related to student research in their promotion files.

9. Funding for Students. Funding was obtained so that students could work on research over the summer. This also gave the department the opportunity to give students and parents the promise of monetary support and see the immediate connection between learning physics and monetary gain. Again any student getting such support was used for real promotional advantages in the department literature and annual reports.

10. Scholarships and Internships. We went to great efforts to have the students apply for scholarships and internships. Several students won very prestigious scholarships (e.g Barry Goldwater scholarship, Council on Undergraduate Research Fellowship, American Physical Society Summer Fellowship) and this had a strong effect on the motivations of the other students. Summer interns were also arranged. One of the best programs here is the 'Research Experiences for Undergraduates' run by the National Science Foundation. Again a great deal of busy work is involved in arranging scholarships and interships but the work is certainly worthwhile. It also helps a lot with recruitment in being able to give examples of the successes of previous students.

11. Seminar Program for Credit. There are several other elements that went into building up the physics program. One was the establishment of a department seminar program. This was specifically designed to provide a meeting place for the majors and faculty. We introduced a program where students could sign up for 1 credit of course work. The requirement was to attend all the seminars and to either write a report on one of them or present a seminar. What was interesting about this was that many students outside of physics also signed up. Many physics majors did not sign up but attended anyway and the group grew. Speakers included faculty from physics and other departments, physics majors and outside speakers. The physics majors would often talk about their research projects and this was a great way for other students to see what opportunities were available. Students also talked about their summer internship experiences. Outside speakers gave talks primarily on research topics, but there were also talks on careers and engineering programs.

12. Recruitment, Advising, Retention. Recruitment and advising appears at first to be another area that seems to be very mundane. However our experience is that the role of the undergraduate physics major advisor is absolutely essential for a successful physics program. The advisor should be very knowledgeable about the employment situation, salaries, current job openings, scholarships, internships, summer jobs, tutoring jobs, housing, international opportunities, graduate record exam, graduate schools, etc. The physics advisor needs to be constantly available, always happy and willing to spend lots of time with the students, have a friendly personality, and do many other tasks too numerous to mention. Not all faculty find all this busy work palatable, but in our experience it is one of the most important factors in *retaining* students once they sign up for the major.

13. Advertising and Brochures. Advertising is another extremely important area that needed attention. One can have the best physics program in the world, but if no one knows about it, then not much is going to happen. The primary way of advertising was to be in touch with physics high school teachers and counselors and to let them know of the new programs that were available with regular mail outs. Teachers were sent information about actual student work as well as general programs so they could give this immediately to their own students. Teachers were also invited regularly to the department seminars and social gatherings. We believe that letting teachers know about the unique aspects of a physics program is one of the

best ways to bring in new majors.

14. Presenting a Plan and Cooperating with Administration. Another aspect of building up the physics program was cooperation and interaction with the university administration. This included not only the deans, provost and chancellor, but also people in the international office, the career center, the counseling center, the affirmative action office, the library, the computer center, etc. It is vitally important to have a good relationship with all of these areas and to explain your plan and future directions. The dean, vice chancellor and chancellor were especially important. When building up a program it is essential to obtain financial commitments and to have these commitments followed through. Often these groups were invited to the department seminars or demonstrations or we provided a tour for administration visitors.

15. Department Team Work and Priority Mission. Finally we should mention the obvious, that all of the above *cannot* be done by one person as every aspect needs attention. No one idea is a quick fix that will work but a sustained concerted effort is needed over several years. We were very fortunate to have a few faculty members who really cared about the program and were willing to work very hard as a team to make it succeed. Once it succeeded then we moved into maintenance.

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